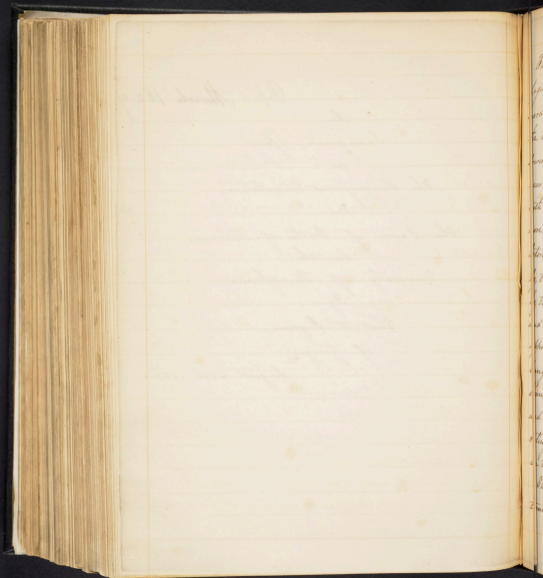


Paper March 1829

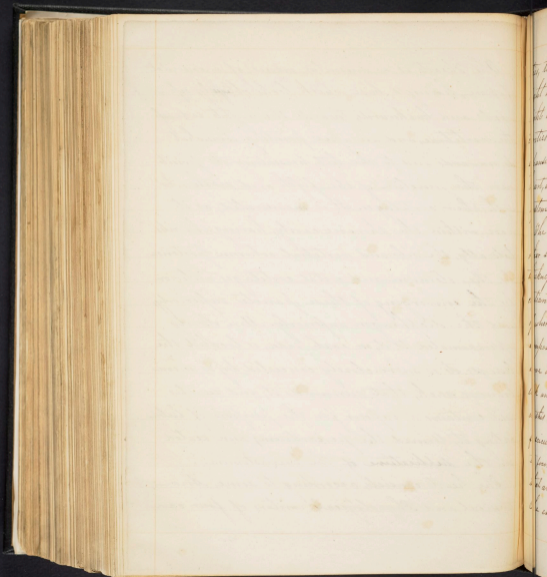
An
Inaugural Essay
on
The Sanguiferous Circulation,
For
The Degree of Doctor of Medicine,
In the
University of Pennsylvania,
By
Thos W. Ingram,
of Georgia.

August 23rd 1828.



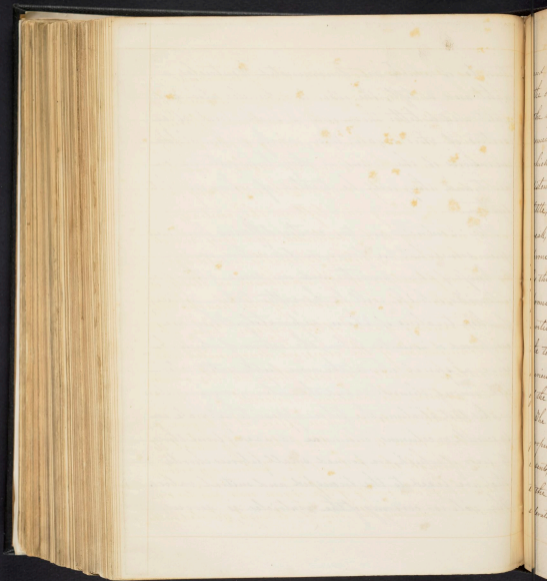
The Heart is a muscular viscus of a conical figure, having a base which looks obliquely upwards and backwards, towards the right side of the vertebrae, and an apex pointing somewhat downwards and to the left, presenting its point near the junction of the fifth and sixth ribs with their cartilages. It is incarcerated, as it were, within the thoracic cavity, having the ribs laterally, the ribs and vertebral column posteriorly, the sternum and costal cartilages anteriorly, the converging of these parietes superiorly, and the diaphragm inferiorly. More closely approximated to it, on each side, is located the lungs; it is more closely concealed by a membranous sack, that surrounds it, and secretes and contains a vapour for the purpose of lubricating it, termed the pericardium; and seated in the duplicature of the mediastinum.

The heart consists, according to some Anatomical and Physiologists writers of four cav-



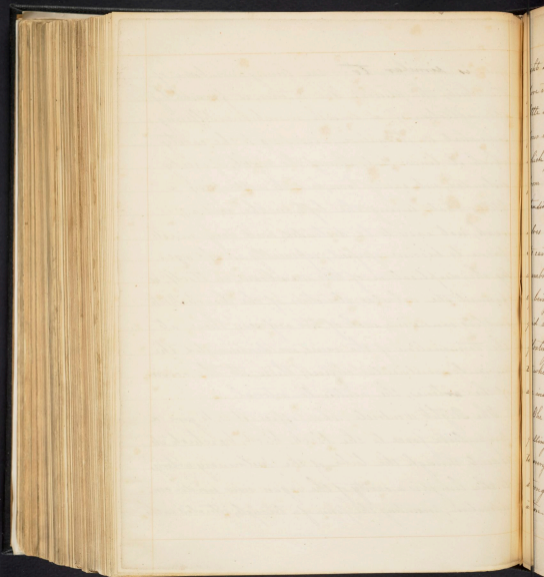
ities, to of which are denominated Ventricles, a right and a left; the other two, Auricles, also, a right and a left: those only I shall treat of as cavities of this organ; these, merely as funnel-like expansions of the veins, as they terminate in the heart, and they will be treated of, when on that system.

The Ventricles are two cavities differing from each other somewhat in form, in dimensions, in the thickness of their parietes, and in some other particularities, which will be hereafter taken notice of, when treating of them separately. They are composed of muscular fibres, the exterior of which observe a spiral course, the more deeply seated interlock among themselves, and the interior, very irregular in this last stratum, the fibres appear to separate in fasciculi or columns (*columnae carnae*), from three to four of which, are formed small fibrous chords, that are fixed to the tricuspid and mitral valves. The exterior covering of the ventricles is serous,



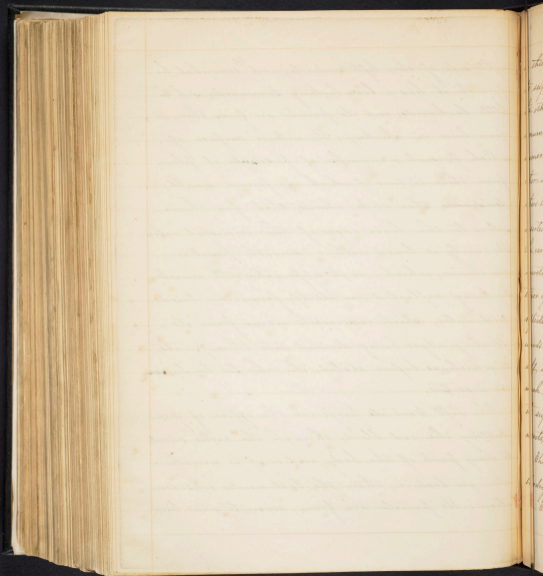
and is similar to the living membrane of the chest, the pleura. The interior, is formed by the reflection of a smooth membrane, differing somewhat in its nature, according to the cavity which it lines: that, lining the right, is easily distended, not easily torn, and it will opify a little; that, lining the left, on the contrary, is weak, not easy to be distended, and very much prone to become opified, especially in old age. By the duplication of this membrane on itself, is formed the valvular structure of the heart. Both cavities consisting each of two orifices: those at the termination of the veins, are denominated the auriculo-ventricular orifices; those at the origin of the arteries, the ventriculo-arterial.

The Right Ventricle, whose office it is, to give a propulsive force to the black blood, by which it is sent, through the tube of the pulmonary artery, to the lungs, is a cavity of the organ now under consideration, presenting the form of a triangle, situated on the



right side of the left ventricle, and somewhat before it; it has a base looking downwards, and a little backwards; and its parietes are from three to four lines in thickness; the interior surface of which presents a number of fasciculi of fibres, from three to four of which are formed small, tendinous, threadlike chords, that fix themselves to the loose edges of the tricuspid valve. Its cavity is lined with a smooth peculiar membrane, which, as it approaches the auricle, by being reflected on itself, forms the tricuspid valve, which receives its name from its floating edges being divided into three points, to which, as before stated, the chordae tendineae are inserted.

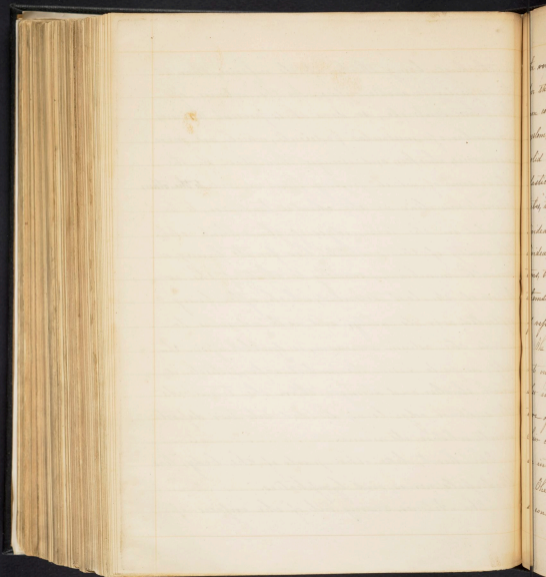
The Left Ventricle performs the office of propelling the red blood, through the aortic canal, to every part of the body, and is of a much stronger texture, than the last under consideration. Its parietes are from seven to nine lines



in thickness, being thicker at its inferior, than at its superior or aortic orifice. As the interior of the other ventricle, so does this, present to view, a number of muscular fasciculi, which are more numerous, thicker, and stronger than those of the other: some of which passing from one side to the other, others terminating in the chordae tendineae, to be inserted in the loose edges of the mitral valve. The cavity of this ventricle has for its lining a smooth membrane, similar to that of the interior of the last described, which, after being reflected over its cavity, and as it advances towards the ostium venosum, is doubled upon itself, so as to form the mitral valve, which is much thicker and stronger than the tricuspid: its superior edge being divided into two departments, whence its name.

The heart, like other parts of the body, has bloodvessels, nerves, and lymphatics.

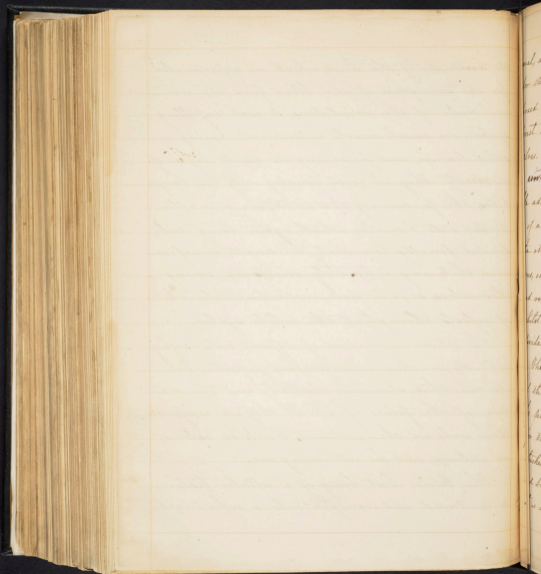
The Arteries, arising out of the orifices of



The ventricles of the heart, which are appropriated for the conveyance of the blood from the common centre of the circulation, to each capillary system, are canals nearly cylindrical, having a solid texture, and possessing no small degree of elasticity. They, at first, forming only two large tubes, the pulmonary and aortic, are soon after divided into branches, which again being subdivided, finally terminate in small ramifications, that very intimately anastomose among themselves, so as to form one entire network of vessels throughout the whole system.

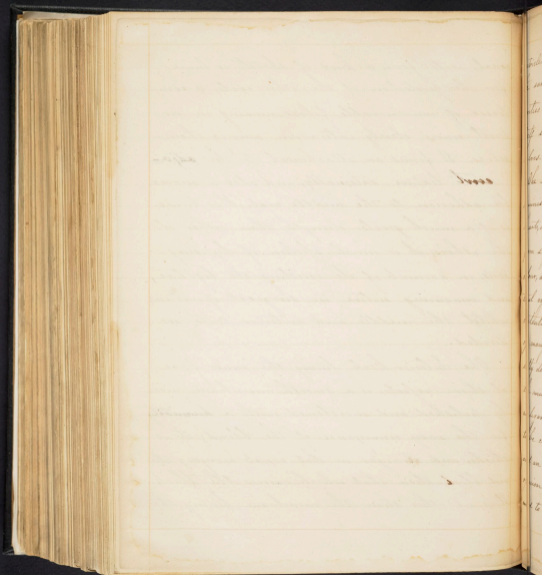
The arteries are composed of different coats, varying not only in their appearance and properties, but also in their strength, elasticity, and the nature of the fibres of which they are composed. Their coats are the following, to wit: an exterior, an interior, and an intervening one.

The Exterior Coat, being of a cellular texture, is condensed and wrought into a cylindrical



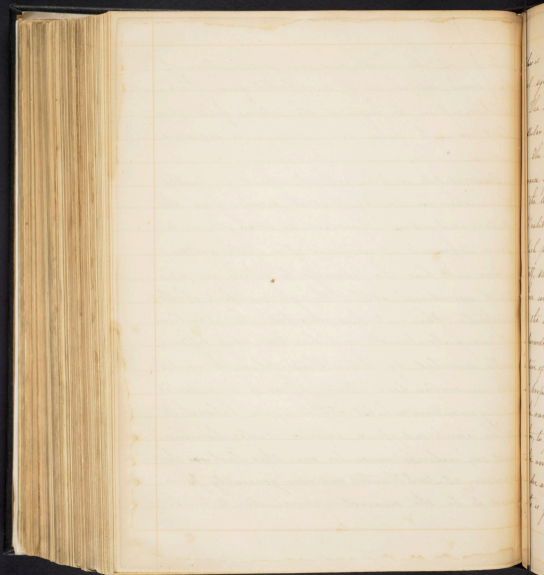
canal, as to form a kind of sheath or tunica for the protection of the other coats, is composed of innumerable fibres running in no direct course, closely interwoven among themselves. It forms an attachment to the adjacent texture externally, and also a moveable adhesion to the middle coat. This tunica is of a much greater strength, than either of the others; it is much spoken of by surgeons, on account of its resisting the ligature, and remaining entire in surgical operations, whilst the middle and interior coats are divided.

The Interior Coat, lining the inner face of these vessels, is a smooth membrane, nicely polished and moistened with a humidity for the easy conveyance of the blood; it is thicker and stronger in that canal carrying the red blood, than that which carries the black. It is no other than the membrane lining the



ventricles of the heart, and is a continuation of the same, which, as it is reflected from those cavities upon the origin of the arteries, folds upon itself so as to form the semilunar or sigmoid valves.

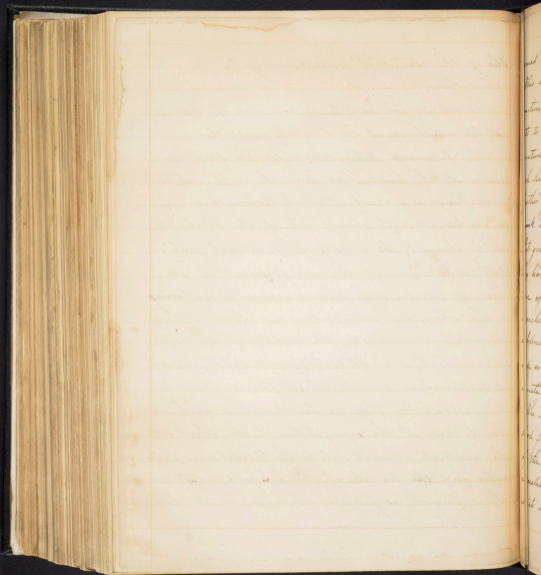
The Middle or Fibrous Coat, which gradually diminishes in thickness as it recedes from the heart, and whose fibres are so arranged, as to form segments of circles, is of a pale yellow colour, and has the firmness to retain its natural cylindrical shape, though emptied of its contents. This coat has attracted the attention of many Anatomists, and has been very differently described by them. Some place it under the muscular head, others appear to consider it as ligamentous, whilst others again believe it to be composed of an exterior elastic lamina, and an interior muscular one: this last was the opinion of Mr. Hunter, and was generally presumed to be the nearest approximation to truth.



This is the coat that gives elasticity to the arterial system.

The arteries are said to be composed of some cellular membrane, of blood vessels, nerves &c.

The Pulmonary Artery, destined for the direct conveyance of the black blood from the right ventricle to the lungs, is a canal of about twelve lines in its calibre, where it springs out of the heart; at which place, by the folding of its internal coat on itself, the semilunar valves are formed. These are three in number with their convex edges adhering to the artery, and their concave ones loose, looking upwards, and having, in the middle of the duplication of each, a small cartilaginous substance, called *Corpusculum Semilunare*, which gives support to the valves, when they are forced against each other, to prevent the regurgitation of the blood into the ventricle, when it dilates itself. Between each valve and the parietes of the artery, a small cavity is formed, as from a dilatation of this last,



named the sinus of Valsalva.

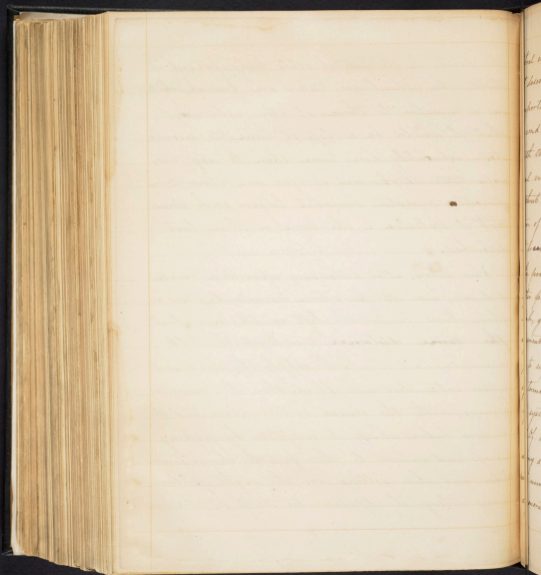
This artery proceeds, directly after its origin, in a direction, upwards and somewhat backwards, till it gets to the posterior part of the aorta, at its curvature, where it bifurcates, sending a trunk to each lung. On account of the left lung being farther from this separation of the artery, the trunk that goes to it is longer and larger, than that going to the right. These trunks, after they have penetrated the parenchymatous structure of these viscera, again divide, sending branches to the several lobuli, which finally subdivide into minute ramifications, that pervade every part of their structure, and terminate in the capillary system.

The Aorta, a canal through which the red blood flows, from the left ventricle to all parts of the body, is at its origin, posterior to, and concealed in front by, the pulmonary artery. As it emerges from the left ventricle of

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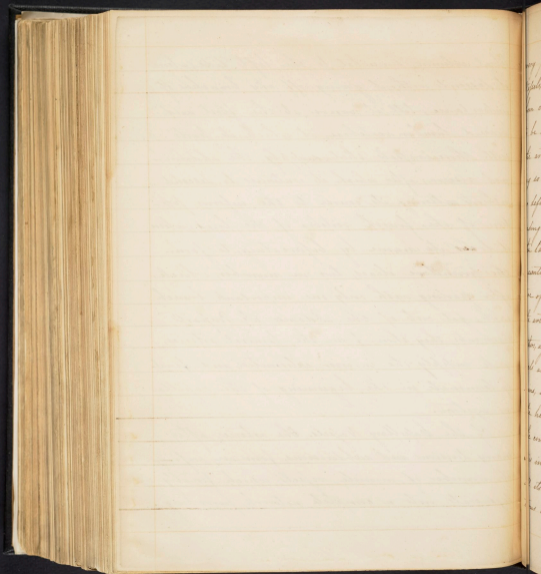
the heart, by its interior coats being folded on itself, the semilunar valves are formed, which are so similar to those of the pulmonary, that it would be a loss of time to describe them separately here, more than to say, they are a little thicker and stronger, and their cornu-
puscul^o Aurant^{is}, somewhat larger: each sinus, that of Valsalva, is the same as those last described. X

This artery, after advancing upwards a small distance, gives off the arteria innominata, two or three lines farther, the left carotid; and about the same distance onwards yet, the left subclavian: all of which supply the head and upper extremities with blood. Here it commences a curve, with the convex surface above and the concave below, which it completes by passing across and anterior to the fourth thoracic vertebra, and then getting over the right pulmonary artery, it approximates itself to the an-

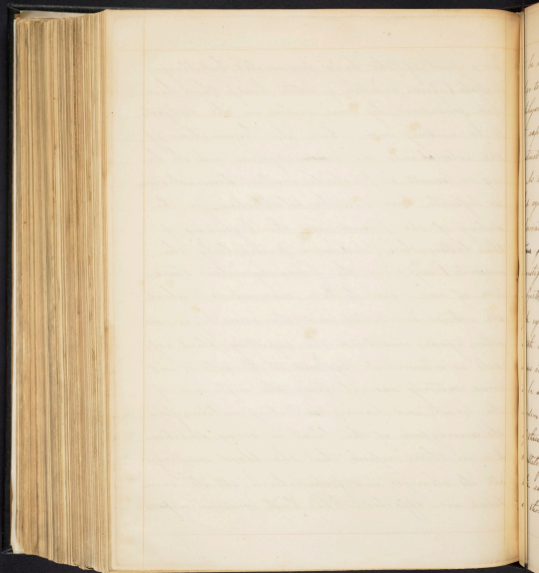


lateral column, somewhat to the left side, where it descends without giving off any branches of importance, till it arrives at the first and second lumbar vertebrae, at which it parts with those vessels that supply the abdominal viscera, after which it continues to descend without altering its course to the inferior portion of the fourth vertebra of the loins, where it loses its name by bifurcating, to form the primitive iliaes, two in number, which, after parting with only one important branch each, get out of the abdomen at Poupart's Ligament: they then form the femoral arteries, go to supply the inferior extremities, and finally terminate in the beginning of the capillary system.

Of the Capillary Vessels. The arteries, after many divisions and subdivisions, form an infinite number of minute vessels, which finally degenerate into a complete network, pervading

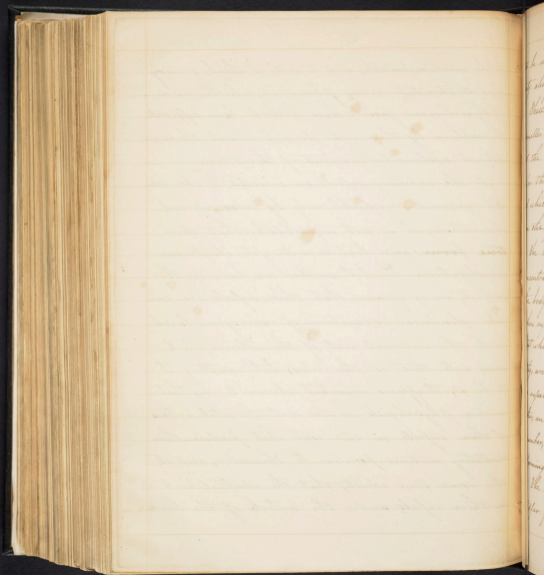


every part of the body, denominated capillary
Vessels, (from capillus, a little hair). These have
been considered, by some writers on the subject,
to be nothing more than the termination of
the arterial into the venous system, which be-
ing so small as to elude ocular Demonstration,
no definite line can be established, for the
ending of the former, and the beginning of
the latter; others, (and more particularly the
ancients,) supposed the parenchymatous struc-
ture of our organs to be a reservoir into which
the arteries terminated and the veins began; and
others, again, considered the capillary blood ves-
sels as intermediate systems to the arteries and
veins, entirely exempt from the influence of
the heart, and having oscillatory motions, for
the conveyance of the blood in every direction.
It is in these vessels, that the blood undergoes
all its changes, and from which, all its secre-
tions are effected. This last opinion appears



to be most reasonable, and it will, I think, go very far to elucidate many phenomena, which, in a physiological point, have hitherto been difficult to explain by those, who do not admit these as distinct systems, independent of themselves.

As the capillary vessels are invisible to the naked eye, and perceptible only by microscopical observations, it is not improbable, that their *true form* and texture will yet elude our investigations. The best authors we have on this subject, are of opinion, that these vessels are simple cylindrical excavations of our organs, lined with the internal coat of the arteries, which runs into that of the veins, but admitting it to be so, it appears somewhat obscure to me, that modern physiologists should eat the vital actions of these vessels in this coat, that produce those oscillatory motions peculiar to themselves, and at the same time admit, that the identical coat in these vessels under the control of the heart,

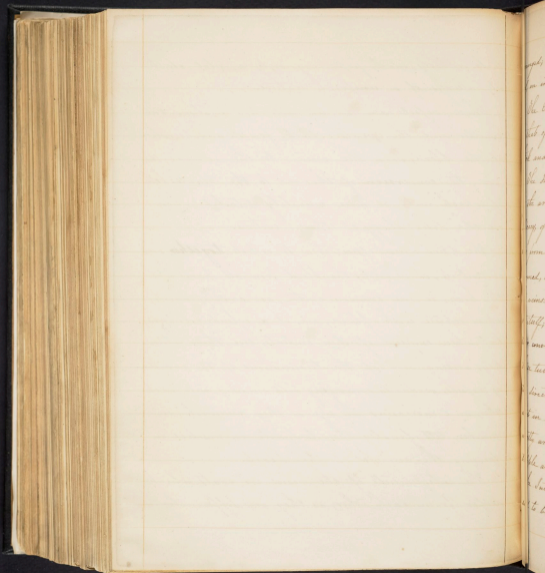


to be entirely inert, possessing only a vital elasticity always of a uniform nature.

These vessels are divided into two systems, the smaller and the greater: that, for the depuration of the blood, from the veins to the arterial; this, for the conversion of the red to the black: both of which will be more minutely detailed, when on the physiology of these systems.

The Veins, whose office it is to collect together, and concentrate, as it were, the blood from all parts of the body, to one common centre, are canals, which, when replete with fluid, are of a cylindrical form, but when emptied of their contents, lose their rotundity, arising out of the terminations of the capillary vessels, gradually converging and running into each other, and increasing in size as they diminish in number, till finally they terminate themselves in forming the auricles of the heart.

The integuments of the veins are coats which differ from each other, as they are differently

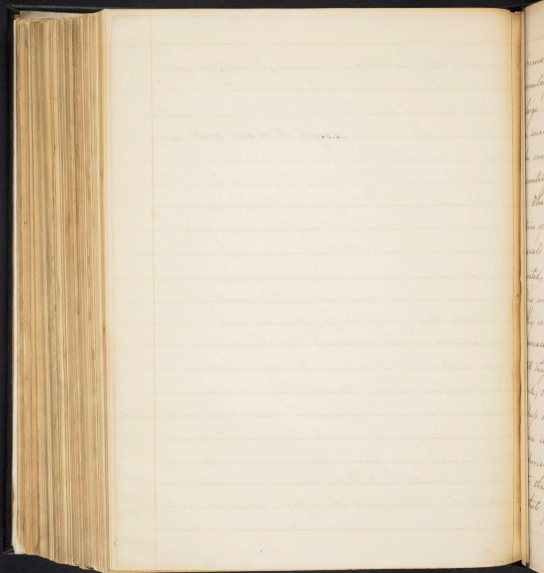


arranged, they are three in number, to wit: an external, an internal, and an intervening coat.

The External Coat of the veins is very similar to that of the arteries, except it is not quite as thick and as strong. X

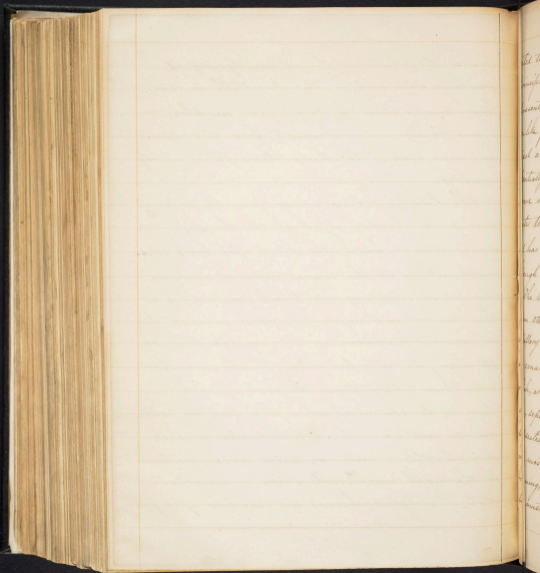
The Internal Coat differs somewhat from that of the arteries, as it is of a greater tenacity and delicacy, of less liability to rupture or to ossify. It is from this coat that all those valves are formed, which are so conspicuous in many of the veins: they are produced by this coat's folding on itself; they are of a sigmoid shape, with their convex edges adhering to the parietes of these tubes, and their concave edges looking in the direction of the heart. They are more abundant in some veins than in others; and are mostly arranged in couples, but sometimes in triple and even quadruple arrangements.

The Intermittent Coat, like that of the arteries, is said to be fibrous, and it differs from it only



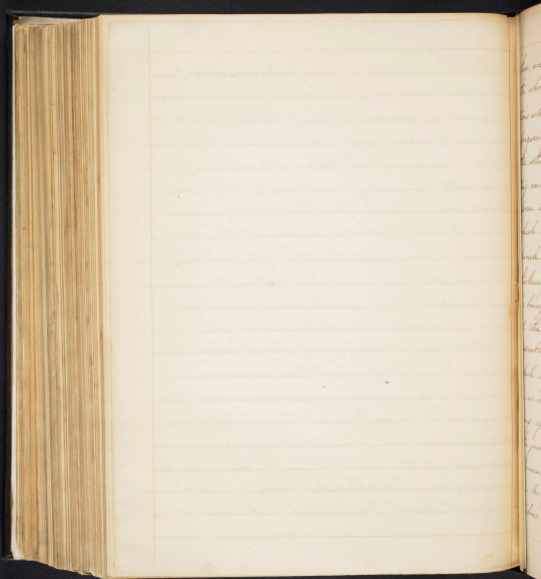
because its fibres run longitudinally, instead of circularly. This coat is more perceptible in the large trunks near the heart, than in those of a smaller size and more remote from this organ. In some parts of the body this coat is entirely wanting.

The Pulmonary Vessels, arising from the terminations of the capillary vessels of the lungs, are those canals through which the blood, after being depurated, returns to the common centre of circulation. They are, at first, very minute and numerous, but as they converge and empty themselves in each other, increase in dimension as their numbers diminish, till they form only two large trunks on each side; these getting from the root of each lung, pass on to the heart, where they form an expansion in uniting with it, denominated the Left Auricle: this is rather concealed by and posterior to the right auricle. Its shape is somewhat that of a square, having an ear-like apex pro-

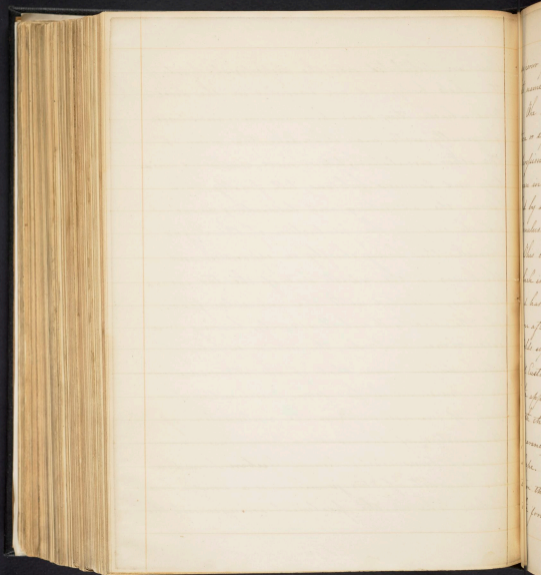


sented to the left of the pulmonary artery. The principal coat of this cavity is muscular, which presents a smooth surface within, except its ear-like portion, whose fibres take on the pectinateal arrangement; its other coats, not being essentially different from those of the veins, deserve no particular description. This auricle unites to and becomes a portion of the heart, and has a free access to the left ventricle, through the medium of the Ostium Venosum.

The veins of the greater circulation, arising from the terminating extremities of all the capillary vessels, from which black blood flows, are canals, at first small and numerous, and which, as they diminish in number, augment in size, separate themselves into two classes, the superficial and the cutaneous: those accompanying most of the arteries of much dimension, by running, one on each side, — therefore their number must almost double that of the arteries;



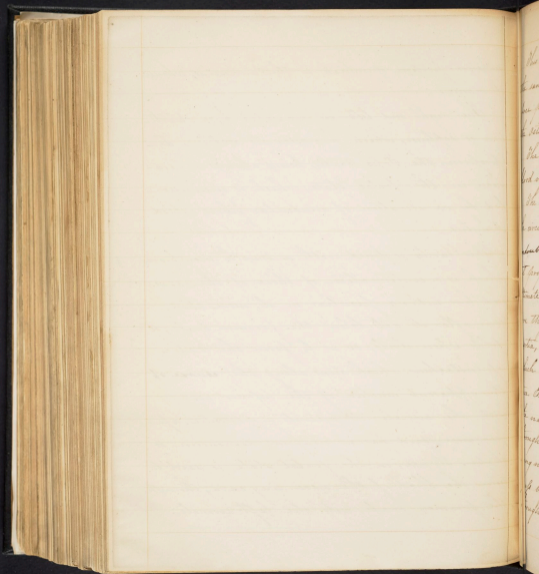
these are distributed over the superficial parts of the whole body, and are irregular in the directions which they run: these divisions anastomose frequently with each other. Like the veins of the other circulation, two or more constantly uniting and forming but one, till finally they form the ascending and descending cavæ which end in the production of the Right Auricle: this, being chiefly an expansion and thickening of the middle coat of the two cavæ, by being blended with the muscular fibres of the heart, is a hollow cavity, bearing some resemblance to a cube, the interior surface of which differs from that of the other auricle, in as much as, it has some peculiarities deserving of our notice. From the continuation of the junction of the cavæ, a prominence is formed transversely, termed *Subiculum Lævæ*. In front of this junction, is a sinus whose fibres take on the ^{1st} fasciculus arrangement, the



superior portion of which is the auricular, whence its name.

The right and left are separated by a partition or septum, which has near its centre a depression, the *Offa Ovalis*, being always a foramen in the foetal state, which is circumscribed by an elevation of muscular fibres, called *Annulus*.

This cavity is lined with a smooth membrane, which is a continuation of those of the cavae, and has nothing peculiar in it, more than, soon after its exit below the foramen ovale, it folds upon itself, so as to form the Valve of Eustachius, which runs along the course of the apparent junction of the inferior cava with the auricle: it presents a crescentic appearance, and has no uniform dimension or shape. Its use, in the foetal state, is said to turn the blood of the ascending cava, through the foramen ovale, into the left auricle.

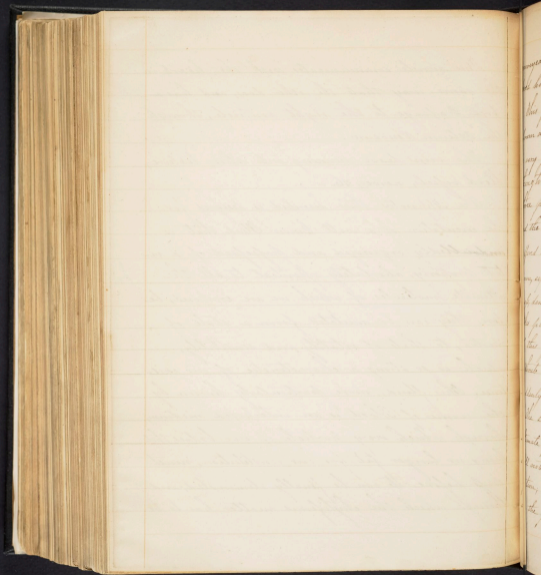


This auricle communicates with the heart in the same way that the other does, and has a free passage to the right ventricle, through the Septum Venosum.

The veins have running into their texture, blood vessels, nerves, &c.

The Apparatus thus described is designed for the circulation of a well known Fluid, that is undoubtedly organized and possessed of a vital property, absolutely essential to all the ultimate molecules of which we are composed, before they can be mutated from a state of inertia, to that of vitality and sensibility, which is so strong a characteristic of our existence. This fluid, more particularly known by the name of Blood, is an interposed medium, through which every particle of our bodies, that being no longer fit for our constitution, must pass before it can be finally eliminated, and through which the chyliferous matter has to be

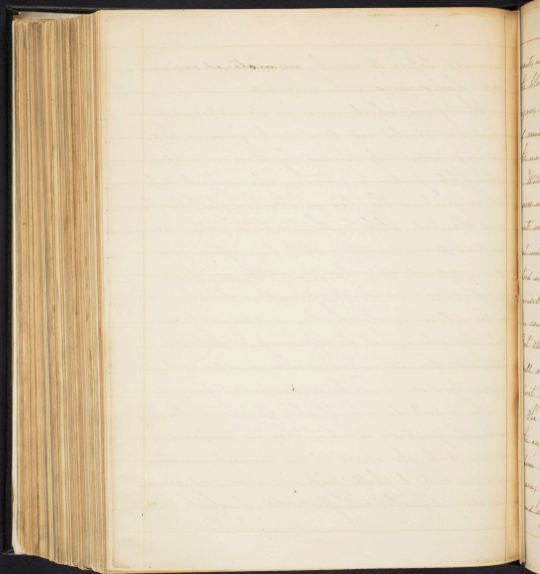
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conveyed, before it can be animalized and rendered homogeneous with ourselves.

This fluid, which varies in its appearance from a scarlet red to a dark grumous hue, is very judiciously divided, by those who have thought proper to write on the subject, into three portions, the Serum, the Coagulable Lymph, and the Red Globules; the two latter will, when suffered to remain still a short time after being drawn, separate from the former into an adhesive mass, denominated the Crassamentum: this change takes place by the death and disorganization of this fluid; but its life may be destroyed without this separation, as when an individual is suddenly destroyed, or by certain putrid fevers, &c.

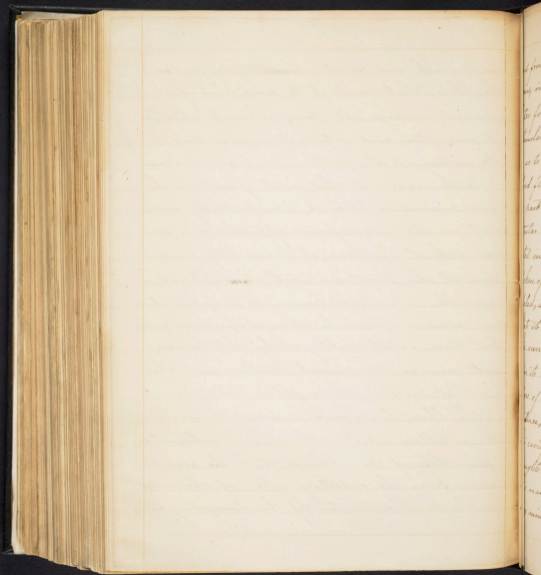
The several divisions of this fluid, and the ultimate particles of which they are composed, will not be the object of my present investigation; but I shall pass over them, and consider the physiological properties of which these



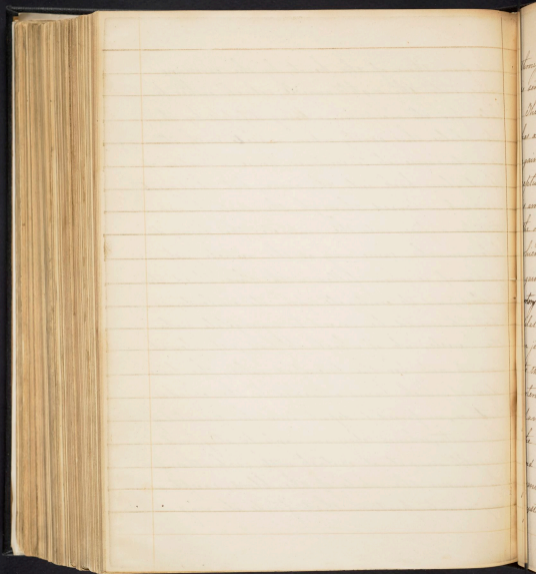
agents, which give that unremitting impulse to the blood, that sends it to every part of our organs, to undergo all those alternate changes of renovation and deterioration, according to the nature of the part into which it flows.

With regard to that vital power which gives momentum to it, it is undeniably inherent in the sanguiferous apparatus and coeval with its existence; it is very little understood at this time, and as it is ~~non~~ material, invisible, and unapprehensive, it may even elude our senses, and never be thoroughly investigated. But those agents employed by this power, will engage my present attention; and the first of these is the right auricle.

The blood, being concentrated, as it were, from the capillary vessels of the inferior extremities, from those of the abdomen, &c, by the ascending cava; from the capillary vessels of the head and superior extremities, by the descending cava;



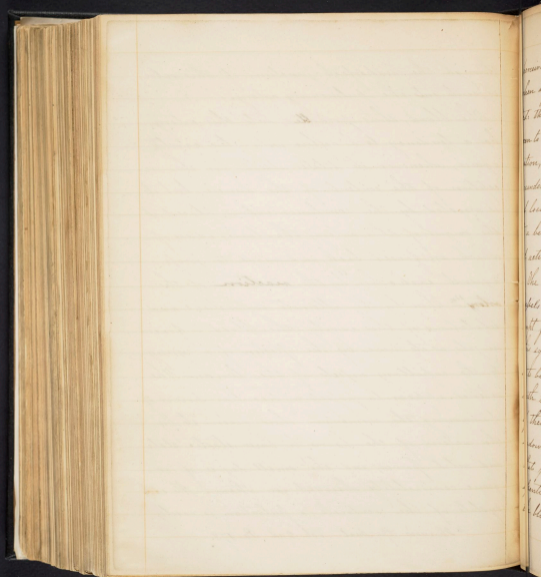
and from those of the heart, by the coronary
veins, into the right auricle, which either di-
lates for its reception or being dilated by it,
stimulates this cavity when replete with it,
so as to cause it to contract: hence a portion of
blood flows back into the earae, but the great
or part is forced through the auriculo-ven-
tricular orifice into the ventricle; this being di-
lated in the same way as the auricle just
spoken of, is when filled with this fluid, stim-
ulated, and it contracts upon its contents, so
that it would be forced to regurgitate into
the auricle, out of which it had just flowed,
were it not for the tricuspid valve, the loose
edges of which being attached to the chordae
tendinae, are forced to depart from the parietes of
this cavity, whence they are wont to stay, and
brought in actual contact with each other, for
this reason the whole of the blood, except a
very minute portion that finds its way through



through the imperfect junction of this valve,
is sent into the pulmonary artery.

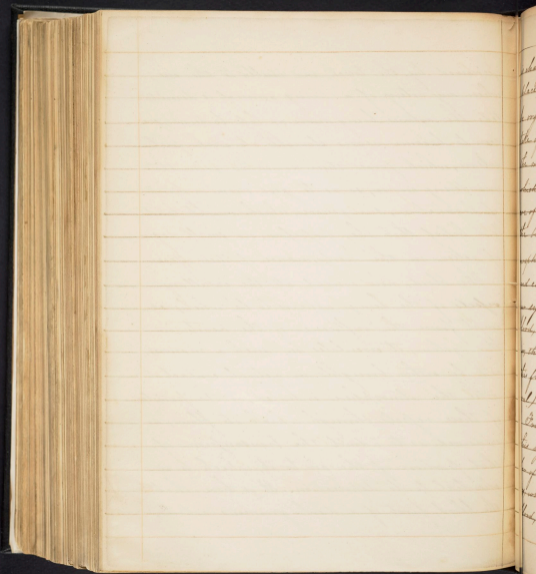
The blood, thus propelled into this artery,
has a tendency to a reflux into this cavity
again, whenever it dilates itself for the re-
ception of the contents of the auricle, but it
is arrested by the semilunar valves, placed at
the origin of this artery, the loose edges of
which are forced back, and made to press
against each other, "by the reaction of the
artery."⁺ Thus by the alternate contractions and
dilations of this cavity, the blood is forced
in jets, as it were by the piston of a syringe,
to the capillary vessels of the lungs. - The
arteries appear to possess a peculiar power of
favoring the momentum thus given it by
the action of the heart, by their elastic state
and vital power, and the small degree of or-
ganic contractility observed in them. At each
systole of the ventricle, a pulsation is easily

⁺ Thomson's Op. Anat. Vol. 2nd. Pa. 173.



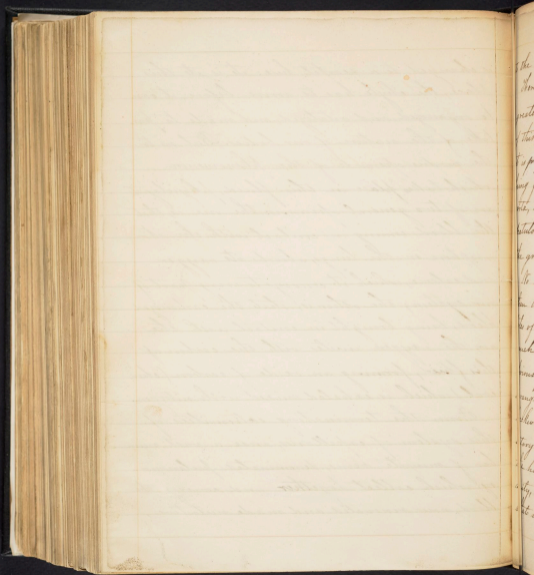
perceived by the touch, and visible to the eye, when any artery of a living animal is denudated. the arteries being more or less tortuous, are seen to become nearer straight at each pulsation, which forces them somewhat from their meandering course, so as to give them a kind of locomotion, *sic generis*, which might lead to a belief that they possessed no small degree of action in the performance of their office.

The blood, now arrived at the capillary vessels of the lungs, appears to be wholly exempt from the influence of the heart: in this system, it circulates in such a manner, as to be either brought in actual contact with the atmosphere inhaled, or the parietes of these vessels through which it flows, so endowed as to admit the transmission of that portion of the air to it, which is so essential to its depuration. It is here that the blood, first of a dark grumous colour,



is changed to a scarlet hue: it is at this place, the chyle has to arrive before it can be organized and vitalized, and made to partake of the nature of our bodies. But as to the *modus operandi* of the phenomenon which takes place in this fluid, physiologists are of two general opinions: the one is, that the blood, coming in contact with the atmosphere in the lungs, absorbs its oxygen and caloric, which it conveys to every part of our system; the other is, that the carbonized blood, being brought in contact with the air, the oxygen unites with the carbon of this fluid, forming an oxide of carbon (char coal) which is exhaled mixed with nitrogen.

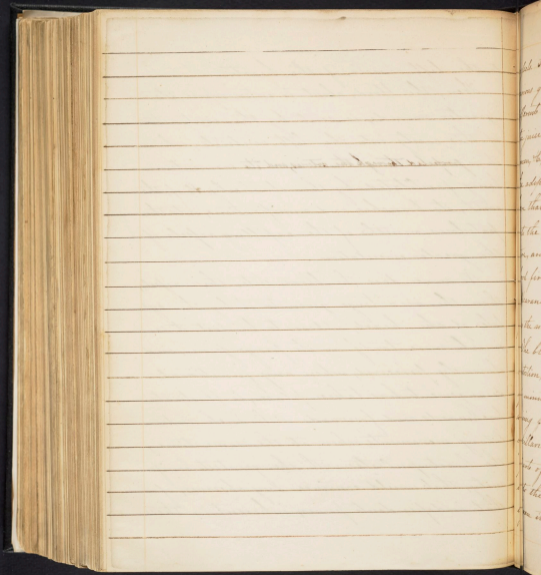
From the terminating extremities of this system of capillaries, arise a vast number of minute veins, denominated *pulmonary*, which collect together and convey the blood, now renovated and made nutritive,



to the left auricle of the heart.

Here, the blood, about to enter upon its greater rounds, is sent by the contraction of this cavity into the left ventricle, whence it is propelled through the aortae, and its momentum being facilitated by the elasticity, &c. of, the aorta, its branches, and ramifications, into the multitudinous mouths of the capillary vessels of the greater circulation.

No sooner does the blood enter these vessels, than the vis a tergo given to it by the systoles of the heart, appears to be lost, it is much more tardy in its progression, and obviously perceived, when any functional derangement has taken place, to fluctuate backwards and forwards with such undulatory movements, when, at the same time, the heart pulsates with the greatest uniformity, that would convince any observer, of that independent power, inherent in these



repels. It is in these capillary tubes that the various glands secrete from the blood, all their different secretions, such as the bile, the pancreatic juice, the saliva, the milk, the urine, the semen, &c; it is this system alone that admits of the adhesion deposition from this fluid; it is here that the fibrina, no longer fluid, enters into the composition of our parenchymatous structure, and becomes solid; it is here that the blood first red and nutritious, assumes a dark appearance, becomes carbonized, and is unfit for the nourishment and support of our body.

The blood, now changed and unfit for farther nutrition, is discharged into an infinite number of minute and at first invisible vessels (veins) arising from the terminating extremities of the capillaries, which accumulate it from every part of our system, and finally empty it into the right auricle, whence it primarily began its circuit.

